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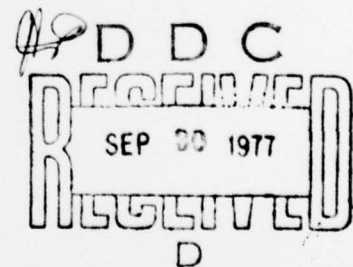
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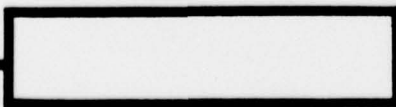
INVESTIGATIONS OF RADIOELECTRIC DISTURBANCES PRODUCED BY
THYRISTOR CONTROL-AND-REGULATION OF VOLTAGE SYSTEMS
ON SEA-GOING SHIPS

by

S. Wankowicz



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INVESTIGATIONS OF RADIOELECTRIC DISTURBANCES
PRODUCED BY THYRISTOR CONTROL AND REGULATION OF
VOLTAGE SYSTEMS ON SEA-GOING SHIPS

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(extra line in Polish Introductory blurb). There are given conclusions for the purpose of lowering disturbances to a level that accords with the technical requirements of the International Electrotechnical Commission and the rebulations of the classifying societies.

Introduction

Thyristor voltage control and regulation subsystems used in ship energy systems are a source of high level voltage and field of radioelectric disturbances, overrunning many times the permissable value in a broad range of frequencies. The level of disturbances depends on the voltage of the switching, the amplitude of the pulses, the angle of the conduction and the frequency of the pulse jump changes, which lead powerfully to their radiation. It is confirmed that thyristors with shorter times of switching generate greater levels of disturbances. A harmful high level of disturbances influences the ship's environment, complicates and even frequently excludes the receipt of radio signals and makes impossible the operation of radio communication and radio navigation systems.

The technical requirements of the Committee 18 of the International Electrotechnical Commission, in its compendium (short blurb) IEC contained in document 432 "Electrical Installation on Shipboard", Orders of the International Special Committee for the Matter of Combatting Radio Disturbances in the compendium CISPR, as well as the regulations of the Classifying Societies, such as: The Polish Register of Ships, the Sea Register of the USSR, Lloyd's Register of Shipping, suggest the permissible limits of radioelectric disturbances at the terminals of systems:

- I. Level W "High" for systems placed under the main deck;
- II. Level N "normal" for systems placed above the main deck;
- III. Level O "lowered" for systems on the control deck and in the neighborhood of a radio station.

The Convention for Safety of Life on the Sea suggests conditions for receiving signals for which an effective value of the field intensity of the signal at a receiver on shipboard, under conditions of reception without disturbances, must amount at medium waves $50 \mu \text{ V/m}$, at intermediate waves and at short waves $25 \mu \text{ V/m}$.

There influences decidedly the receipt of radio signals not only the value of the voltage, and the field of the disturbances, but above all, the ratio of the voltage of the signal used to the voltage of the disturbance at the output of the receiver. Order No. 339 of the International Consulting Committee for Radiocommunication Matters, in its compendium CC&R suggests the required ratio of these voltages for radio services: sea, land, and air.

Forseeing the Level of Disturbances at the
Time of Planning of the Ship

In the case of processing an electrical installation, especially with use of thyristor subsystems for control and

regulation of voltage, the planner can determine a foreseen level of disturbances. In the planning phase of a ship it is possible to use suitable means indeed, required for the suppressing of excessive disturbances. A thyristor voltage regulator acts in a manner not intended as a generator of noise of high frequency supplying with noise energy directly the ship's electric network.

Disturbances from thyristor noise sources on the outside of a system penetrate by two routes. The voltage of the disturbances is carried through the feed wires of the electric network. The field of the disturbances is radiated directly onto the outside of the system from the thyristor subsystem. Eliminating the carrying through of the disturbances on only one of the routes does not lead to their complete suppression.

The planner of a shipboard electric installation in which there are used thyristor subsystems for control and regulation of voltage, of generators, of elevator motors, of a cathode protection station etc. must possess discrimination in the area of:

- the permissible level and the character of disturbances, depending on the region of the ship the electrical and electronic systems are installed;
- the means of defense used against the foreseen disturbances in order to insure correct operation of the radio, radio-navigation, hydroacoustic systems and the system for the conversion and registration of digital data;
- of native and international regulations having to do with noise matters and of measuring methods. The planner must determine in a program of tests the places of measurement of disturbances (noise) on the prototype ship at the time of tests at sea.

Investigations and Measurement of Radioelectric Disturbances

For years the Center for Ship Technology has been carrying out investigations and measurements on thyristor systems for regulation and control that are used in the ship industry as well as in electric networks on prototype ships, freight, fishing, and research (ships).

By investigations of generated harmful disturbances with the producer of systems there are included thyristor subsystems as in Figure 1. It illustrates the results of measurements on an unsymmetric disturbance voltage before filters of the thyristor subsystem, as a function of frequency.

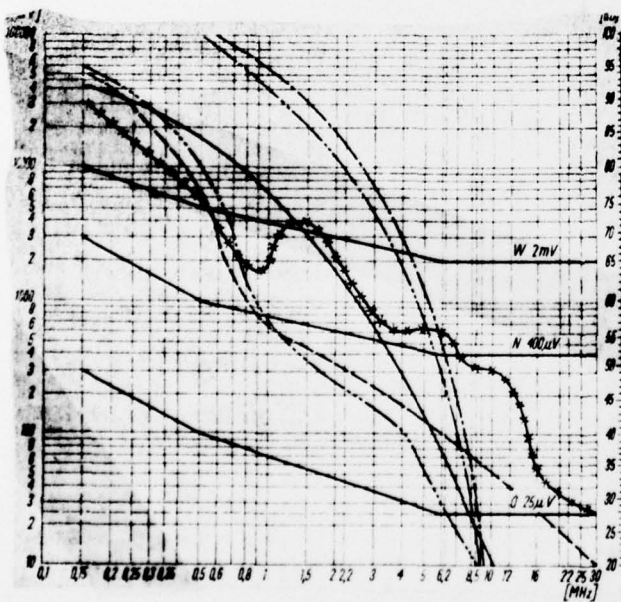


Figure 1. Voltage of disturbances (noise) from a thyristor subsystem. — Regulator of the voltage of a generator of 400 kVA of the type Tur 405 (with thyristors TY 120 Spl) of the Warsaw Electronic Factory in Glinia; — — Asphalt impregnated regulator of a generator of 80 kVA (with thyristors TL-250) of the Institute of Electrotechnology in Gdansk (Danzig); - . - . Control system of a load elevator 1.5 (3 tons) (with 42 T 10 thyristors) of the Institute of Electrotechnology in Gdansk; - . . . System for controlling an on-deck crane 5 tons (with TY 290S thyristors) of Towimor (?) in Turunia; - . . . Control

system for a cathode protecting station AS-9010 (with T100/300 thyristors) of Famor and Bydgoszcz; —x Subsystem which feeds a telephone switchboard ACC-20/80 (with BTP 10/50 and BTP 18/100 thyristors) of the Gdansk Teletechnical plants, Telcom Telmor in Gdansk.

The investigated subsystems for control and regulation are supplied with varied types of thyristors, they differed moreover in their parameters of voltage, current, and time of switching.

On the basis of measurement results it is confirmed that pulse thyristor subsystems produce too much radioelectric noise voltage in a broad band of frequencies up to 30 MHz, which overruns many times the noise levels accepted by the International Electrotechnical Commission IEC. The level of disturbances is the greater the lower the frequency.

On international danger frequencies and 500 kHz call frequencies as well as in the range of lighthouse frequencies 285-325 kHz, given in the Radiocommunication Regulation of the International Telecommunication Union UIT - the permissible "lowered" level of radioelectric disturbances foreseen for a radiocabin and a navigation cabin is overrun 1000 times (60 dB). The "normal" level of disturbances (noise) foreseen for the systems installed on the deck of the ship is overrun 100 times (40 dB). Moreover the "high" level provided (foreseen) for systems installed in engine rooms and machine control centers is overrun 30 times.

Next there were carried out investigations of radioelectric disturbances produced by thyristor subsystems under conditions of use: on the research vessel Professor Siedlecki of capacity 3000 RT and the hunting trawler Zwieroboj. The first of them has a combustion-electric prime mover of power 3 x 700 kW with a control thyristor in a DC current loop. The regulators are from the Siemens firm. The regulator of the propeller (screw) motor is of the type GbUGL-D \pm 400/150 Mer 2D, input 3 x 250 V/58 A, output \pm 330V/70 A. Current regulator A type GbUG-400/100 Mer 2D, input 3 x 175 A, output \pm 210 V/66 A. On the ship there were installed three converter regulators of the same type GbUS-D \pm 400/100

Mer 206, input 3x 175 V 32A, output ± 210 V/38A. The ZWIEROBOJ of capacity 1971 RT has a combustion electric prime mover, of power 3x750 kW, 1200 A/625 V with thyrister use in a DC current system. On the ship there are installed regulators from the Siemens firm. The regulator of propeller motor A and the regulator of the 2nd propeller (screw) B is of type E 44070-A 4030, input 3x250 V, load 70 A, output ± 300 V. The current regulator (of) A type E 44070-A 4031 input 3x250 V, output ± 300 V load 120 A.

The measurements were carried out on the Baltic sea at a distance of more than two nautical miles from shore. There was measured the noise voltage on the main gear boxs bars without anti-noise filters. The gearbox has been placed in the machine control central CMK. There was measured the level of noise in the radio cabin after using filters on the cables feeding the gearbox of the radio systems. There were installed filters of the FA type with an attenuation of 100 dB in a band of frequencies 0.15-500 MHz.

The results of measurements of noise in the electric network on the ships has been presented in Figure 2.

Investigations of Radioelectric Disturbances

After the installation of an anti-noise filter there followed a lowering of the noise voltage below the permissable level "lowered" provided for a radio cabin. From the point of view of the necessity for correct and not disturbed operation of the radio, navigational, and radar systems, installed on sea-going ships, one must currently use on the feed cables of the system anti-noise filters, which is associated with the selection of suitable filters. Well known firms, for instance Siemens or ASEA are not in a position to insure (guarantee) thyristor systems

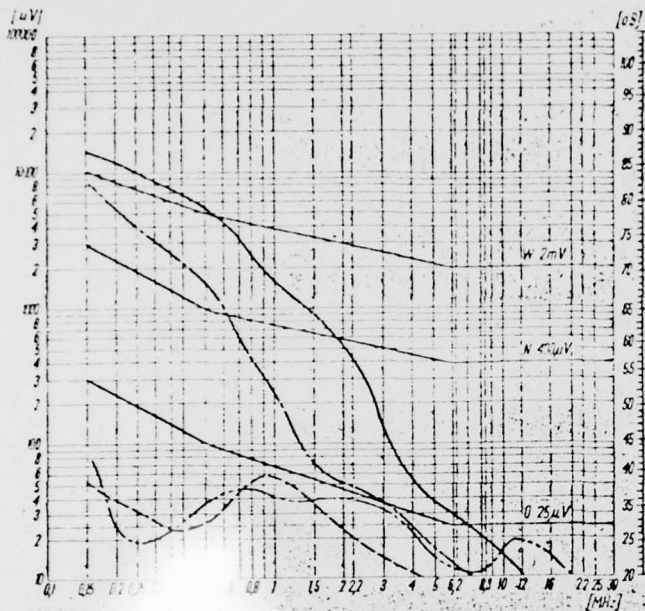


Figure 2. Voltage of disturbances (noise) in a ship's electrical network.
 — unfiltered electrical network in the control-steering on the ship PROFESSOR SIEDLECKI; -.-. unfiltered electrical network in the control-steering central on the ship ZWIEROBOJ; -.-.-. filtered electric network in the radio cabin on the ship PROFESSOR SIEDLECKI; .-. filtered electrical network in the radio cabin on the ship ZWIEROBOJ.

for control and regulation, against harmful side

influences, which appear as an unintended generation of radio-electric noise disturbances. This matter appears all the more glaring in the next period as a result of the development of thyristor systems which will be used in an armature circuit the prime mover of a ship of many powers (motors?) above 2000 kVA.

CONCLUSIONS

1. In the stage of planning of a ship it is necessary to provide security for the electric network against radioelectric disturbances (noise) and especially of a ship with a combustion-electric prime mover supplied with thyristor subsystems for regulation and control.
2. The simplest and most economical currently is the securing of the feed cables that feed the radio cabin the navigation one, the hydroacoustic one and the computing center with anti-noise filters of an attenuation of 100 dB, installed on the outside wall of the cabin in the place of input of the cable into

the cabin. On research ships it is necessary to use individual separated galvanized electrical circuits (networks) that supply the electronic radio, navigational, hydroacoustic, and calculating system, in order to insure them against disturbances proceeding from thyristor subsystems for regulation and control.

3. Special attention must be turned to the level of disturbances appearing on the international danger frequencies, call frequencies, and navigational radiogoniometric ones, in agreement with the requirements contained in the Convention for Safety of Life at Sea, and of the International Consulting Committee for Radiocommunication Matters CCIR.

4. On each prototype of ship it is necessary to carry out measurements of the disturbances (noise) in the radio and navigation cabins during sea tests in the presence of a representative of the Polish Register (Registry) of Ships, of the skipper, and of the shipyard, in agreement with the requirements of the regulations of the classification society.

5. It is necessary to develop research Model(ling) operations connected with the use of a prime mover with thyristors in an armature circuit of power around 2500 kVA, taking into consideration simultaneously means of insuring against excessive radio-electric disturbances.

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